US005904207A

United States Patent [19]

Rubbo et al.

[11] **Patent Number: 5,904,207**

[45] **Date of Patent: May 18, 1999**

[54] **PACKER**

[75] Inventors: **Richard P. Rubbo**; **Stephen Reid**, both of Aberdeen, United Kingdom

[73] Assignee: **Petroleum Engineering Services Limited**, Aberdeen, United Kingdom

[21] Appl. No.: **08/841,328**

[22] Filed: **Apr. 30, 1997**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/641,598, May 1, 1996, Pat. No. 5,685,369.

[51] **Int. Cl.**[6] **E21B 33/12**

[52] **U.S. Cl.** **166/123**; 166/195

[58] **Field of Search** 166/123, 66.7, 166/120, 129, 195, 208, 217, 182

[56] **References Cited**

U.S. PATENT DOCUMENTS

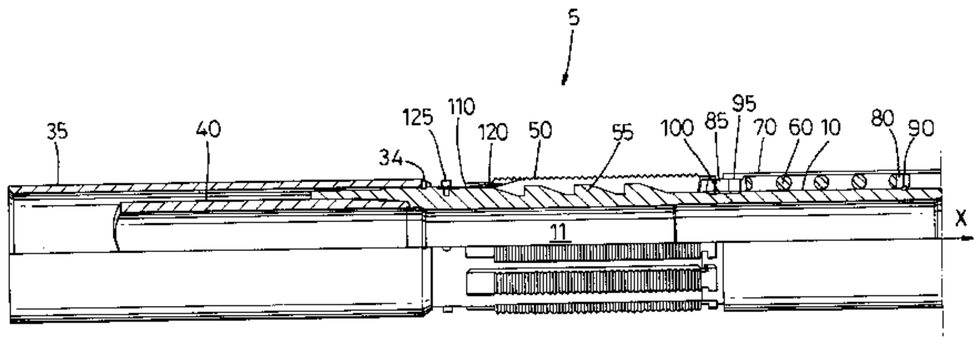
4,307,781	12/1981	Preston, Jr. et al.	166/123
5,224,540	7/1993	Streich et al.	166/118
5,558,153	9/1996	Holcombe et al.	166/66.7 X
5,701,954	12/1997	Kilgore et al.	166/119

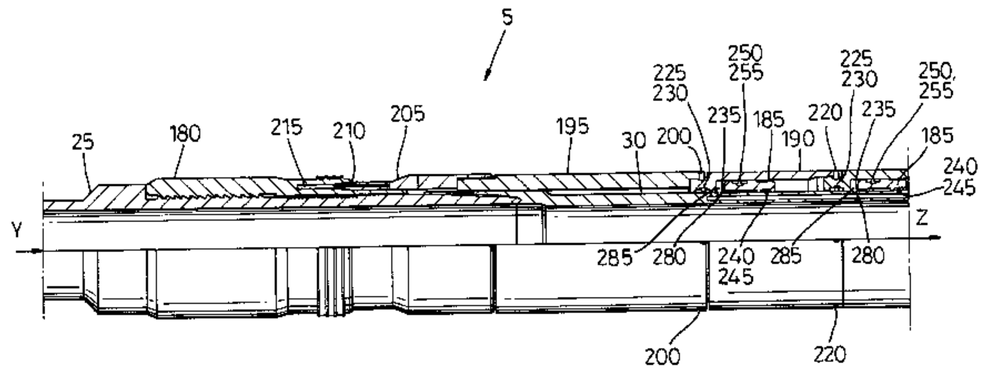
Primary Examiner—Frank Tsay
Attorney, Agent, or Firm—Thelen Reid & Priest, LLP

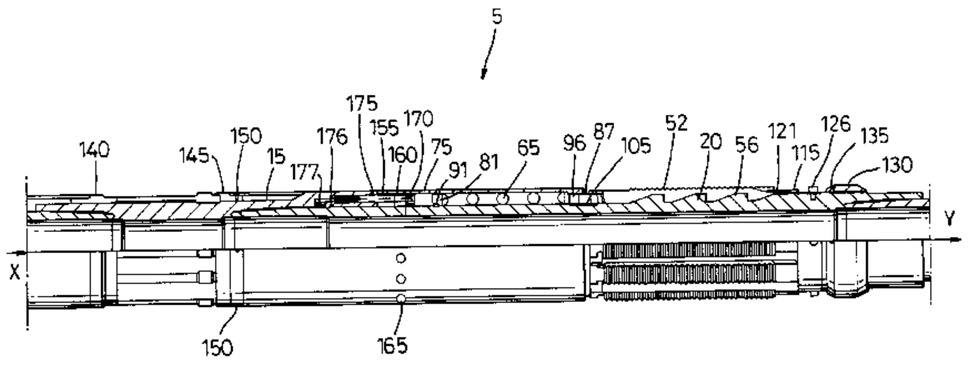
[57] **ABSTRACT**

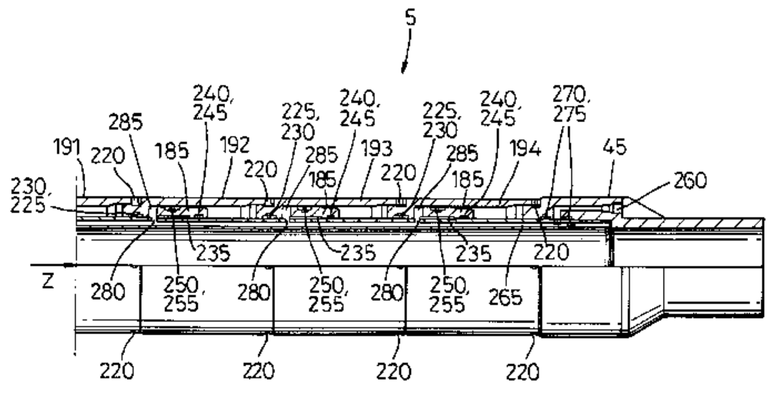
An improved packer (plug/bridge plug) for us in the exploitation of subterranean oil and/or gas reserves comprises a mechanism (**50,52**) for anchoring the packer (**5**) within an oil/gas well, a mechanism (**55,56,60,65**) for setting the anchoring means (**50,52**), a sealing element (**180**), and a mechanism for setting the sealing element, wherein the mechanism (**60,65,155**) for setting the anchoring means (**50,52**) comprises a biasing mechanism (**60,65**), and means (**155**) for releasably retaining the biasing mechanism (**60, 65**) in an energized state, wherein, in use, when the releasable retaining mechanism (**55, 56**) are released the biasing mechanism (**60,65**) act on the anchoring means (**50,52**) so as to cause the anchoring mechanism (**50,52**) to move into a deployed position.

20 Claims, 4 Drawing Sheets









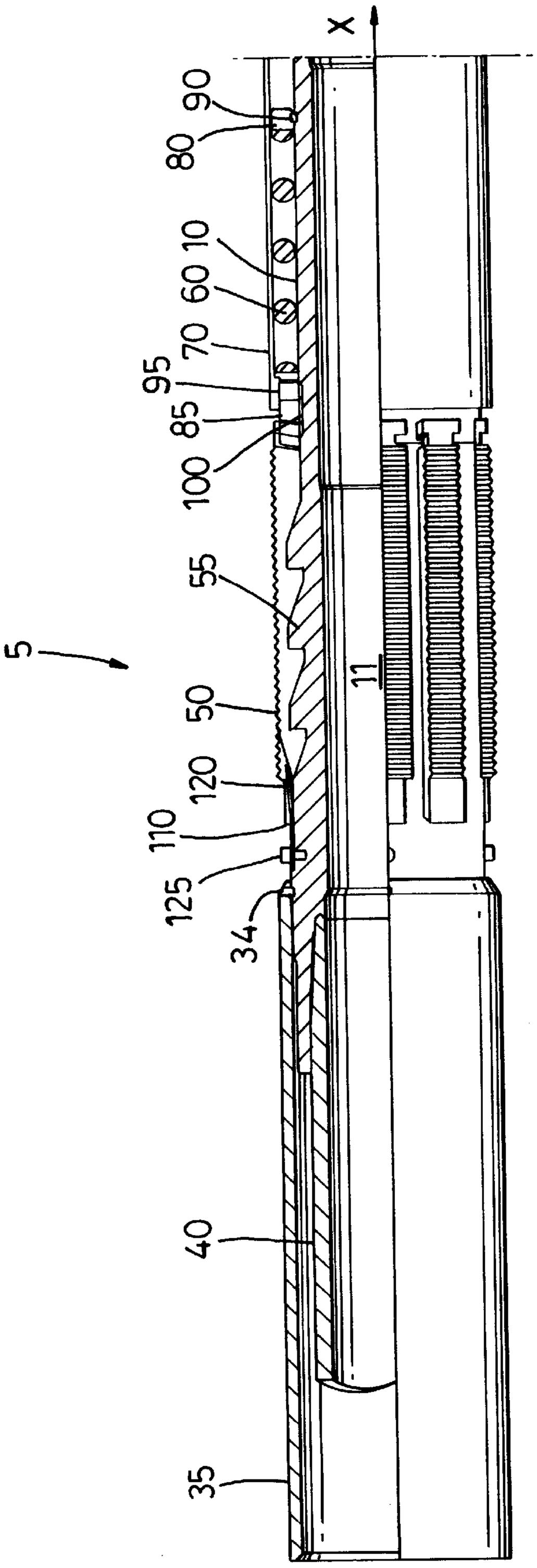


Fig. 1(A)

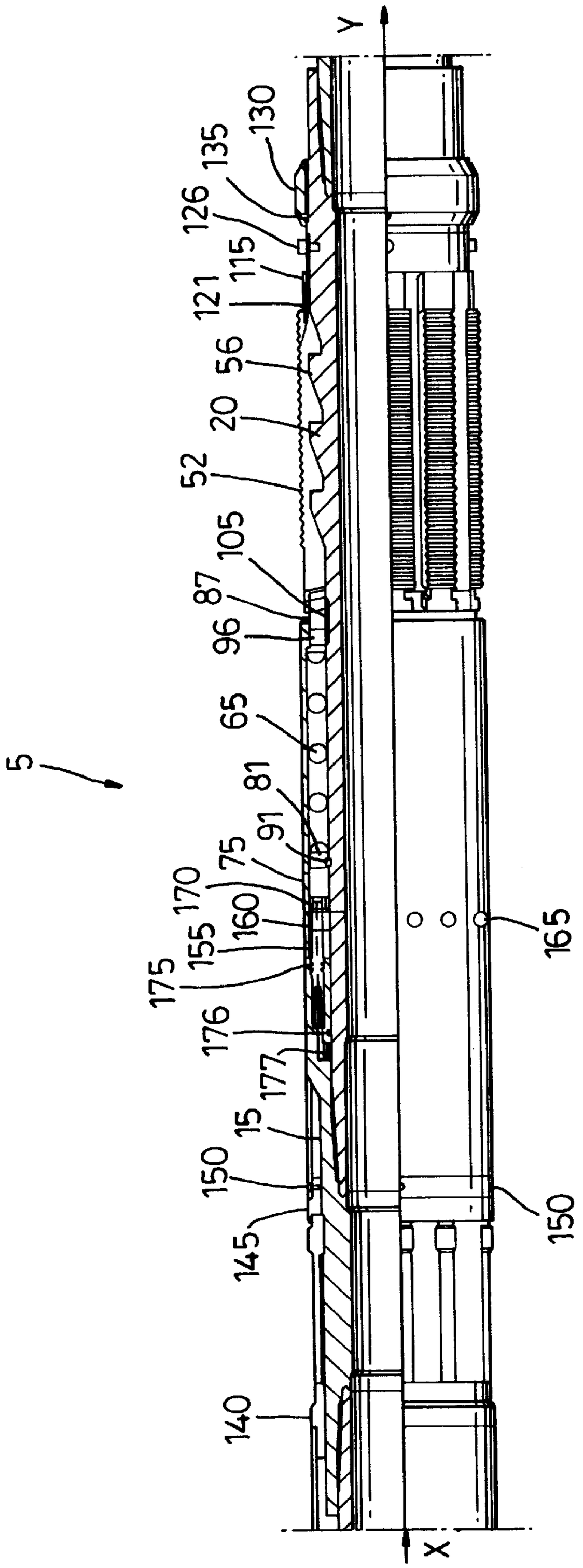

Y
130
135
126
115
121
56
20
52
105
87
96
65
5
81
91
75
170
160
155
175
176
177
15
150
145
140
165
150
X

Fig. 1(B)

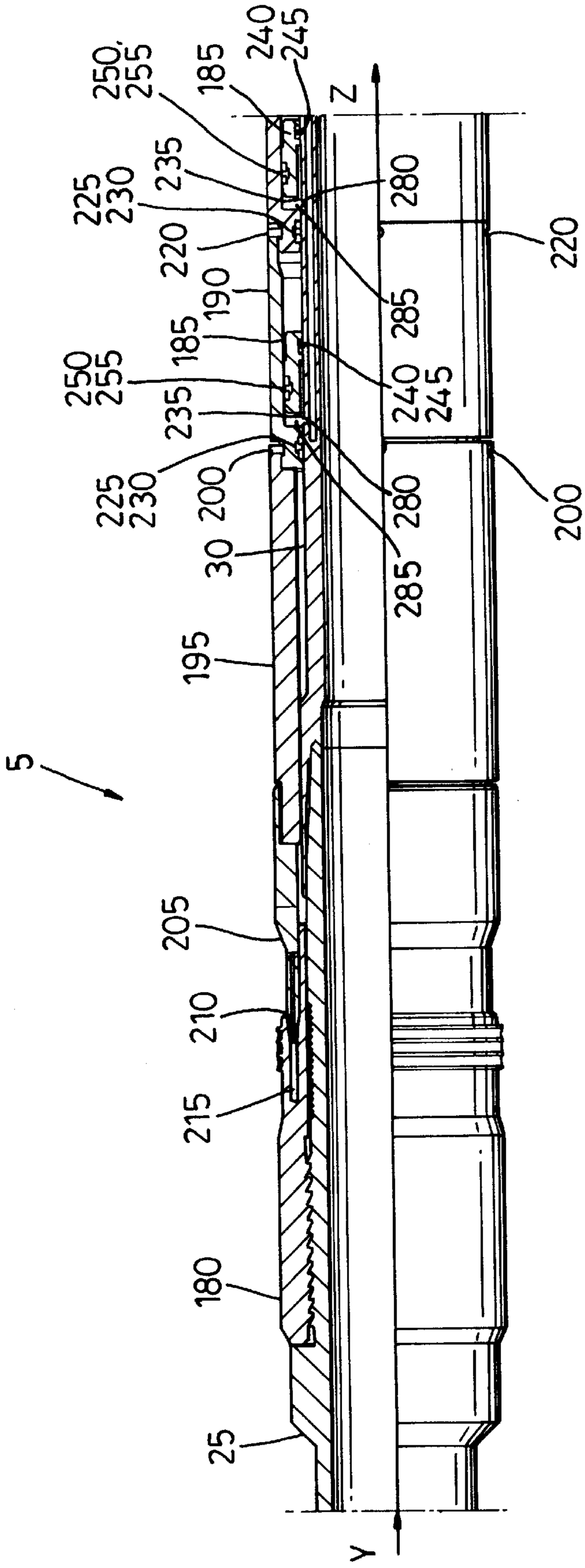

5
250
255
185
240
245
Z
225
230
235
280
220
220
190
285
185
250
255
240
245
235
225
230
200
280
200
30
285
195
205
210
215
180
25
Y

Fig. 1(C)

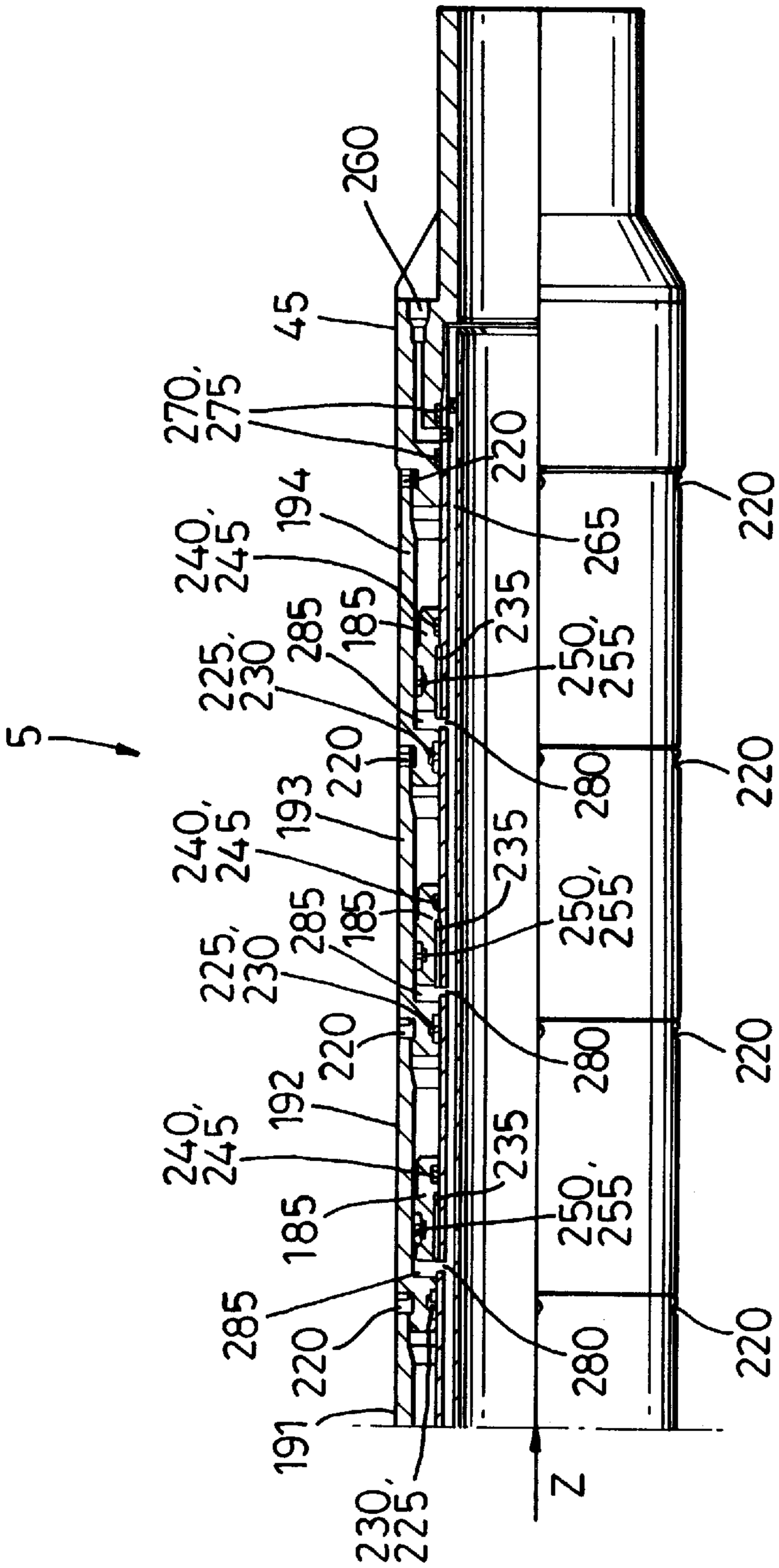

5
260
45
270, 275
220
194
240, 245
265
235
185
285
225, 230
250, 255
280
191
230, 225
Z

Fig. 1(D)

PACKER

This is a continuation-in-part of U.S. application Ser. No. 08/641,598, filed May 1, 1996 now U.S. Pat. No. 5,685,369.

BACKGROUND OF THE INVENTION

The present invention relates to a packer for use in the exploitation of subterranean oil and/or gas reserves, which reserves may be located off-shore.

Packers, sometimes referred to as plugs or bridge plugs, are known. Packers normally comprise a sealing (or packing) element, and may include setting and releasing mechanisms and/or anchoring slips.

Packers may be used in operations such as multiple zone completion, zone isolation and testing.

Many existing packers utilise elastomeric sealing elements which, after prolonged exposure to a down hole environment, are prone to perish with a corresponding loss of sealing efficiency. Existing packers further suffer from slippage (creep) within down-hole casing.

The present invention seeks to obviate or mitigate at least some of the aforementioned disadvantages.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a packer comprising means for anchoring the packer within an oil/gas well, means for setting the anchoring means, a sealing element, and means for setting the sealing element, wherein the means for setting the anchoring means comprises biasing means, and means for releasably retaining the biasing means in an energised state, wherein, in use, when the releasable retaining means are released the biasing means act on the anchoring means so as to cause the anchoring means to move into a deployed position.

The biasing means may be in a compressed state when in an energised state.

The packer may include a body which carries at least one flared portion on an outer surface thereof, an inner surface of the anchoring means being shaped that the anchoring means can rest on the flared portion when the anchoring means are in a non-deployed position, releasing of the biasing means causing the anchoring means to be urged against the at least one flared portion thereby causing the anchoring means to move radially outward into the deployed position.

Longitudinal movement of the anchoring means relative to the at least one flared portion therefore causes radial movement of the anchoring means.

The at least one flared portion may flare away from the body at an angle of between 5 to 30 degrees.

The releasable retaining means may comprise an explosive bolt.

The anchoring means may comprise a first and second longitudinal spaced sets of slips.

In such case the biasing means may comprise first and second helical springs, each spring acting on the corresponding set of slips, in use.

According to a second aspect of the present invention there is provided a packer comprising means for anchoring the packer within an oil/gas well, means for setting the anchoring means, a sealing element, and means for setting the sealing element, wherein the means for setting the anchoring means includes an explosive bolt.

According to a third aspect of the present invention there is provided a packer comprising means for anchoring the packer within an oil/gas well, means for setting the anchoring means, a sealing element, and means for setting the sealing element, wherein the means for setting the sealing element include at least one hydraulic chamber, means for applying hydraulic pressure to the at least one hydraulic chamber, and means moveably responsive to the applied hydraulic pressure, wherein, in use, when the moveable means respond to the applied hydraulic pressure the movement thereof causes the sealing element to move radially outward thereby forming a seal.

The packer according to any of the foregoing aspects of the present invention may be an annulus packer capable of forming a seal between two zones in an annular space between a tubing string and a casing of a well.

Alternatively, the packer according to any of the foregoing aspects of the present invention may be a tubing packer capable of forming a seal between two zones within a tubing string.

The packer according to any of the foregoing aspects of the present invention may preferably be of a non-retrievable type, although it may be envisaged that the packer may be of a retrievable type.

The sealing element of the packer according to any of the foregoing aspects of the present invention may be made substantially from metal/metal alloy.

In such instances the metal/metal alloy may, for example, be a durable corrosive resistant metal/metal alloy preferably compatible with corrosive resistant metal alloys such as chrome nickel.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings which are:

FIGS. **1**(A)–**1**(D) a partially sectioned representation of a packer according to an embodiment of the present invention.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Referring to FIGS. **1**(A)–(D) there is shown an packer according to an embodiment of the present invention, generally designated **5** comprising a number of bodies hereinafter identified as an upper body **10**, a main body **15**, a lower body **20**, a seal mandrel **25** and a setting mandrel **30**. Said bodies are substantially cylindrical, are provided with a central bore **11** and are connected to one another in the sequence noted above. The upper body **10** is shown in FIG. **1**(A) to be connected via a lock screw **34** to a tubular guide member **35** and a portion of tubing string **40**. The setting mandrel **30** is further connected to a bottom sub **45** which is connectable to a further portion of tubing string. In this way the packer **5** is integral with a length of tubing string.

The upper and lower bodies **10**, **20** are each provided with a set of radially arranged slips **50**, **52** which rest upon a series of tapered cones **55**, **56** (flared portions) present upon respective outer surfaces of the bodies **10**, **20**. The inner surfaces of the individual slip members **50**, **52** are fashioned such that they mirror the profiles of the taper cones **55**, **56** and hence allow the slip members **50**, **52** to be held close to the bodies **10**, **20** when not deployed.

To enable the slips **50**, **52** to be deployed there is provided a slip setting mechanism including a pair of helical springs **60**, **65**. The springs **60**, **65** are respectively located between the outer surface of the upper and lower bodies **10**, **20** and the inner surfaces of a pair of cylindrical spring housing

members **70, 75** surmounting said bodies **10, 20**. Each spring **60, 65** is held longitudinally between a spring washer **80, 81** and a slip retainer **85, 87**. The spring washers **80** are anchored to the upper and lower bodies **10, 20** by c-rings **90, 91** while the slip retainers **85, 87** each incorporate a dog ring **95, 96** which locates in a circumferential groove **100, 105** present on the outer surface of each body **10, 20**.

The uppermost end **110** of the upper slips **50** and the lowermost ends **115** of the lower slips **52** are retained against the upper and lower bodies **10, 20** respectively by a plurality of elongate spring members **120** and cap screws **125, 126**. The lower body **20** is further provided with a gauge ring **130** which is attached thereto by a plurality of lock screws **135**.

The upper and lower spring housing members **70, 75** are each attached to the respective upper and lower slip retainers **85, 87** and said spring housing members **70, 75** are, prior to the deployment of the slips **50, 52** connected to one another by virtue of a latch **140** and a latch retainer **145** surmounting the main body **15**. The latch **140** is attached to the upper spring housing member **70** while the latch retainer **145** is secured to the lower spring housing member **75** by a plurality of screws **150**.

Prior to deployment of the slips **50, 52** the springs **60, 65** are held in compression by an explosive bolt **155** retained between the main body **15** and a drive ring **160** attached to the lower spring housing member **75** by a plurality of retaining screws **165**. The bolt **155** is additionally secured to the drive ring **160** by the provision of a retainer **170**. Sealing between the bolt **155** and the main body **15** is achieved by virtue of a pair of O-rings **175**.

Sealing between the main body **15** and the lower body **20** is achieved by virtue of an O-ring **176**. Provided between an upper facing surface of the lower body **20** and a lower facing surface of the main body **15** is a core **177**.

The sealing and setting mandrels **25, 30** carry a metal seal element **180** and means to set the seal element **180**. The setting mandrel **30** is surmounted by a plurality of annular pistons **185** and a plurality of piston covers **190, 191, 192, 193** and **194**. In this embodiment there are five pistons **185** and five piston covers **190, 191, 192, 193** and **194**.

The uppermost piston cover **190** is connected to a cylindrical connector member **195** by a plurality of set screws **200**. The connector member **195** is further connected to an expander ring **205**. The expander ring **205** is provided with a tapered portion **210** which, prior to deployment of the seal element **180**, rests at or near an entrance to a circumferential slot **215** provided within the seal element **180**.

The lowermost piston cover **194** is connected by a plurality of shear screws **220** to the bottom sub **45** and the five piston covers **190–194** are connected to one another in sequence by a plurality of shear screws **220**. The piston covers **190–194** are further each provided with a T-seal **225** and a pair of back-up rings **230** at their interface with the setting mandrel **30**.

The pistons **185** are each rigidly connected to the setting mandrel **30** by a respective lock ring **235**. Sealing between each piston **185** and the setting mandrel **30** is achieved by a respective O-ring **240** and a respective pair of back-up rings **245**. A seal between each piston **185** and its respective piston cover **190–194** is provided by a T-seal **250** and a pair of back-up rings **255**.

The bottom sub **45** is provided with an aperture **260** which communicates with a longitudinal extending annular chamber **265** present within the setting mandrel **30**. Seals comprising an O-ring **270** and a pair of back-up rings **275** are provided both above and below the point at which the bottom sub aperture **260** connects to the setting mandrel annular chamber **265**.

A plurality of ports **280** are provided in the outer wall of said annular chamber **265**, said ports **280** serving to connect said annular chamber **265** with piston chambers **285** defined between an upper face of each piston **185**, an inner surface of each respective piston cover **190–194** and the setting mandrel **30**. The number of piston chambers **285** corresponds to the number of pistons **185**. Thus in this embodiment there are five piston chambers **285**.

In use, the packer **5** according to this embodiment is run on a tubing string **40** into a casing of a subterranean well (not shown). Once the packer **5** is at a required depth the upper and lower slips **50, 52** are deployed to set the packer **5** within the casing by causing the slip **50, 52** to come into contact with an inner surface of the casing.

Slip **50, 52** deployment is initiated with the triggering of the explosive bolt **155** by a flux generator (not shown) run into the central bore **11** of the packer **5**, for example, on wireline. The flux generator generates on magnetic field within the packer **5** which when positioned within the area of the bolt **155** is sensed by core (coil) **177** contained on the outside of the lower body **20**. The effect of the magnetic field within the core is to generate a flow of current therein which connects to a firing circuit of a detonator of the explosive belt **155**. Once the explosive bolt **155** has sheared, the lower spring housing member **75** is no longer connected to the main body **15** and hence the lower spring **65** is free to expand and act against the lower slip retainer **87**. The expansion of the lower spring **65** results in a downward movement of the lower spring housing member **75** which in turn causes the latch retainer **145** to disengage from the latch **140** and allows the upper spring **60** to expand and act against the upper slip retainer **85**.

The action of the upper and lower springs **60, 65** respectively against the upper and lower slip retainers **85, 87** forces the slips **50, 52** onto the upper and lower mandrel tapered cones **55, 56**. Hence the slips **50, 52** are deployed radially outwards until they come into contact with the casing under the biasing influence of springs **60, 65** respectively.

Once the slips **50,52** have been deployed and the packer **5** is held within the casing, the seal element **180** is deployed hydraulically. The necessary hydraulic pressure may be provided in a number of ways including placing a temporary plug in the tubing string below the packer **5** and applying the required pressure directly, or by using a wireline setting tool capable of independently generating the required pressure locally and positioning it between upper and lower seals such that the setting tool's hydraulic output acts upon a seal setting mechanism.

Irrespective of the method used to provide the necessary conditions to set the seal member **180**, pressurised fluid enters the bottom sub aperture **260** and passes to the setting mandrel annular chamber **265**. The fluid then passes into the piston chambers **285** and causes each piston covers **190–194** to advance up the setting mandrel **30**. The movement of the piston covers **190–194** shears the shear screws **220** and further causes the connector member **195** and expander ring **205** to advance up the sealing mandrel **30**. The tapered portion **210** of the expander ring **205** is thus forced into the seal element circumferential slot **215**, thereby causing the seal element **180** to expand radially outwards and seal the space between the casing and the packer **5**.

The embodiment of the present invention hereinbefore described is given by way of example only, and is not meant to limit the scope of the invention in any way. Modification

of the disclosed embodiments would be apparent to a person skilled in the art without departing from the invention.

At least some embodiments of the packer according to the present invention provide at least some of the following advantageous attributes:

A. Sequencing—The casing anchoring slips **50**, **52** can be activated and thus tubing movement effectively prevented prior to energising the metal seal **180**.

B. Pressure activation—The slips **50**, **52** are activated independently of applied differential setting pressures allowing the tubing to be landed in any desired axial load state; thus tubing stresses can be optimised.

C. Tubing movement is not required which allows setting against solid shoulders such as liner hangers. Since the packer **5** disclosed is not retrievable tubing workover is achieved by either torquing out the left hand connection at the top of the packer **5** or more practically, by cutting the tubing directly above this location. This no tubing movement setting feature allows a second packer to be stung into the upper receptacle of the first packer, providing string continuity for wireline operations.

D. Tubing induced loads are transmitted from the packer **5** through the slips into the casing with-out transferring through any components related to the metal sealing element, or the hydraulic setting components.

E. The multi-cones slips employed are believed to produce a uniform casing stress distribution over the slip length.

F. Integration of the cones with the mandrel achieves the rated combination load capacity within the geometric constraints presented by the desired casing and tubing strings.

G. Since the maximum applied loads are greater than the setting loads incremental slip penetration and tubing movement can not be eliminated. The seal **180** is expected to be tolerant of the resulting movement within the casing. However, springs **60**, **65** minimise this effect by inducing the slips **50**, **52** to take up this movement when it occurs so that it is not repeated on subsequent load cycles.

H. Tubing manipulation may be employed, depending on the completion arrangement, following activation of the slips **50**, **52** and prior to seal activation in order to further minimise the one time dynamic effects on the metal seal **180**.

I. The hydraulics for actuation are carried within the packer **5**. Pressure can be directly applied against a temporary plug in the tail pipe or lower casing. This approach requires the application of relatively high setting pressure differentials on the order of 10,000 psi. Alternatively, a wireline setting tool capable independently generating the required pressure locally may be positioned within upper and lower seal bores such that the setting tool's hydraulic output acts on the packer.

J. In a modified embodiment the piston chambers **285** could be ported directly to the packer bore and thus obviate the need for the bottom sub aperture **260** and setting mandrel annular chamber **265**.

The disclosed embodiment is an annulus packer, ie, a packer which forms a seal between two zones in the annulus between the (drill) tubing string and the well casing. However, it should be appreciated that the invention is not limited to annulus packers. Indeed tubing packers, ie, packers which form a seal between two zones within the tubing, are within the scope of the invention. The invention is, however, particularly advantageous to annulus packers.

Finally it should be understood that herein the terms lower/lowermost/upper/uppermost are used for ease of description and are intended to indicate a preferred orientation of the packer **5** within a well-bore. This is, however, only a preferred orientation and the packer **5** may be employed in a contrary orientation if so desired.

We claim:

1. A packer comprising:

anchoring means for anchoring the packer within an oil/gas well;

first setting means for setting the anchoring means, the first setting means including means for biasing the anchoring means and releasable retaining means for releasably retaining the biasing means in an energised state;

sealing means for sealing the packer in the oil/gas well; and

second setting means for setting the sealing means;

wherein in use, when the releasable retaining means are released, the biasing means act on the anchoring means so as to cause the anchoring means to move into a deployed position.

2. A packer as claimed in claim **1**, wherein the biasing means is in a compressed state when in an energised state.

3. A packer as claimed in claim **2**, wherein the packer includes a body which carries at least one flared portion on an outer surface thereof, an inner surface of the anchoring means being shaped that the anchoring means can rest on the flared portion when the anchoring means are in a non-deployed position, releasing of the biasing means causing the anchoring means to be urged against the at least one flared portion thereby causing the anchoring means to move radially outward into the deployed position.

4. A packer as claimed in claim **1**, wherein the packer includes a body which carries at least one flared portion on an outer surface thereof, an inner surface of the anchoring means being shaped that the anchoring means can rest on the flared portion when the anchoring means are in a non-deployed position, releasing of the biasing means causing the anchoring means to be urged against the at least one flared portion thereby causing the anchoring means to move radially outward into the deployed position.

5. A packer as claimed in claim **4**, wherein longitudinal movement of the anchoring means relative to the at least one flared portion causes radial movement of the anchoring means.

6. A packer as claimed in claim **5**, wherein the at least one flared portion flares away from the body at an angle of between 5 to 30 degrees.

7. A packer as claimed in claim **4**, wherein the at least one flared portion flares away from the body at an angle of between 5 to 30 degrees.

8. A packer as claimed in claim **1**, wherein the releasable retaining means comprises an explosive bolt.

9. A packer as claimed in claim **1**, wherein the anchoring means comprises first and second longitudinal spaced sets of slips.

10. A packer as claimed in claim **9**, wherein the biasing means comprises first and second helical springs, each spring acting on the corresponding set of slips, in use.

11. A packer as claimed in claim **1**, wherein the packer is an annulus packer capable of forming a seal between two zones in an annular space between a tubing string and a casing of a well.

12. A packer as claimed in claim **1**, wherein the packer is a tubing packer capable of forming a seal between two zones within a tubing string.

13. A packer as claimed in claim **1**, wherein the packer is a non-retrievable type.

14. A packer as claimed in claim **1**, wherein the packer is a retrievable type.

15. A packer as claimed in claim **1**, wherein the sealing element is made substantially from metal/metal alloy.

16. A packer as calimed in claim **15**, wherein the metal/metal alloy is a durable corrosive resistant metal/metal alloy.

17. A packer as claimed in claim **16**, wherein the metal/metal alloy is compatible with corrosive resistant metal allows such as chrome nickel.

18. A packer as claimed in claim **15**, wherein the metal/metal alloy is compatible with corrosive resistant metal alloys such as chrome nickel.

19. A packer comprising:

anchoring means for anchoring the packer within an oil/gas well;

first setting means for setting the anchoring means, the first setting means including an explosive bolt;

sealing means for sealing the packer in the oil/gas well; and

second setting means for setting the sealing means.

20. A packer comprising:

anchoring means for anchoring the packer within an oil/gas well;

first setting means for setting the anchoring means;

sealing means for sealing the packer in the oil/gas well; and

second setting means for setting the sealing means, the second setting means including at least one hydraulic chamber, hydraulic pressure-applying means for applying hydraulic pressure to the at least one hydraulic chamber, and moveably responsive means for moveably responding to the applied hydraulic pressure;

wherein in use, when the moveably responsive means respond to the applied hydraulic pressure, the movement thereof causes the sealing means to move radially outward, thereby forming a seal.

* * * * *